Send Hubble to the Moon

SIR—The proposal of Bahcall in *Nature* of 22 June last year[1] to establish an international institute for astrophysics is an important one. In particular, their suggestion of taking to geosynchronous orbit the 2.5-metre test mirror developed for the Hubble Space Telescope (HST) programme is an interesting possibility.

This is an example of reducing astronomical costs as well as sharing them. In low Earth orbit, the HST must be serviced during the next solar cycle, which may be a costly exercise, possibly compromised by the flight availability of the Space Shuttle. In geosynchronous orbit, on the other hand, an HST instrument would need less servicing, and would provide direct data access (see ref. 2 for a discussion of 90-minute operations). It would have direct command and control, three times the efficiency of observations, and ambient-cooled optics (being further from Earth).

I would like to take this suggestion one step further, and point out that the Hubble test mirror could be taken to the Moon, again as part of a cost-effective strategy. NASA has recently conducted three workshops[3-5] addressing physics and astronomy from the Moon, the first of which contributed to a presidential decision that a return to the Moon would be the next major goal of the US space programme. It is clear that the Moon, as our nearest neighbour, offers distinct advantages for space astronomy over low-Earth orbit and geosynchronous orbit, and over any planetary initiative.

Taking the Hubble test mirror to the Moon, at the onset of the programme, could serve as a focal point for the lunar initiative, placing the programme's emphasis on science and astronomy. In this scenario, the test mirror with modern instrumentation and redesigned actuators for a structural 1/6-gravity environment at a lunar base (rather than zero-gravity in Earth orbit) would be put in place immediately at the landing site on the second or third manned mission to the Moon. (There may be unmanned excursion missions, landing before the manned phase.)

A 10,000-pound Hubble instrument is 4.5 metric tonnes, one of the very payload weights currently used by NASA's Office of Exploration[6] in its preliminary models for the manned flights there. With the approval of the US Congress, one can easily imagine the Hubble 2.5-metre mirror at a man-tended lunar base within this decade (by the year 2000, one of the schedule dates now in use[6]).

The existing proposals[3,5,6] on astronomy from the Moon have been described as "lacking vision". Using the Hubble test mirror in this way, that is, putting it in place at the onset (the second lunar landing) at low cost (as an 'off-the-shelf' instrument) could catch the public imagination and muster the scientific support required for a visionary approach (see H.J. Smith in ref. 5 for discussion). This must not compromise the Hubble programme itself, it must be international in scope, and it must be followed by a more ambitious set of observatories using larger, higher-quality mirrors (since the Hubble test mirror does not meet the needs of space astronomy in the twenty-first century).

The Hubble emplacement, early on, would also serve as a testbed for determining requirements and problems for astronomy from the Moon as the initial outpost evolves into a mature lunar base.

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1. Bahcall, J.N. *et al. Nature* **339**, 514 (1989).
2. Lindley, D. *Nature* **338**, 199 (1989).
3. Potter, A. E. & Wilson, T. L. (eds) *Physics and Astrophysics from a Lunar Base — First NASA Workshop, AIP Conf. Proc.* **202** (American Institute of Physics, New York, 1990).
4. Jones, W. V., Kerr, F. & Ormes, J. (eds) *Particle Astrophysics: The NASA Cosmic Ray Program for the 1990s and Beyond, AIP Conf. Proc.* **203**, (1990).
5. Mumma, M. J. & Smith, H. J. (eds) *NASA Workshop on Astrophysics from the Moon, AIP Conf. Proc.* **207**, (1990).
6. NASA's *Report of the 90-Day Study on Human Exploration of the Moon and Mars*, submitted to US National Space Council, 20 November 1989.

Global warming

SIR—Perhaps you have not received any correspondence that presents a positive or optimistic outlook for the changes that are predicted to accompany or be a consequence of global warming? The good news that large areas of Canada and the Soviet Union may become more conducive to agriculture seems largely discounted. More optimistic speculations could centre on how the results of the greenhouse effect might circumvent the burning of fossil fuels for energy. Apart from the argument that we may need to burn less fuel for heating in a warmer world, going further, desert areas could become the 'oil wealth' of the future if they were turned over to massive-scale production of solar-generated electricity. This abundant electricity might be used to make hydrogen for use in internal combustion engines. Or perhaps there could be solar-powered desalination plants to produce fresh water for use in, say, irrigation programmes. Such schemes would require labour, but might appeal to people forced to move if their homes became uninhabitable as a result of climatic change.

Such an optimistic outcome would, of course, require planning, management and co-operation between nations on an unprecedented scale. Such intergovernmental co-operation may seem unlikely, but an unbalanced, gloomy outlook surely cannot help it to come about. I hope you will encourage the avoidance of doomsaying in such matters.

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Australia prize

SIR—Tania Ewing's story on the Australia Prize (*Nature* **344**, 692; 1990) needs correction.

Professor Allen Kerr did not isolate the bacterium responsible for crown gall disease. That was done long ago. He was, however, the first to show that pathogenicity in *Agrobacterium tumefaciens* could be transferred from one strain to another.

This transfer was then shown by the groups associated with Professors Eugene Nester and Jeff Schell to involve the large tumour-inducing plasmid (pTi). This was the beginning of the development of an effective plant transformation system, to which their groups have contributed so many advances.

Ewing errs again in attributing to them the genetic engineering of a benign strain of *Agrobacterium* to ensure continuing effectiveness of the system of biological control of crown gall disease. That was due entirely to Kerr's group.

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Crisis in education

SIR—It seems that there is a dearth of applications for postgraduate research awards this year, but there is a widespread reluctance on the part of supervisors to admit how few applications have been received for the awards on offer, as they fear that the poor application rate will discourage funding bodies from continuing their support.

This is a mistake. Rather than concealing the situation, we should be shouting and screaming about the low number of aspiring postgraduates, as it is symptomatic not of problems within individual departments, but of a major crisis within the whole higher education system that must be addressed now. A dearth of postgraduates now will be a constraint on the future development of research in this country.

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